

Hydroxy compounds (A Level)

A-Level Chemistry 9701 · Topic 32 revision notes

Everything from the 2 lessons of this topic on a few pages: the key idea of each lesson, the diagram to remember, the points to learn and the traps examiners set. Read it, cover it, test yourself.

1. Alcohols: further reactions

2. Phenol

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1 Alcohols: further reactions

Syllabus 32.1

An acid HA is strong when its anion A^- is **stable**, so the order of acidity follows the stability of the anion. In an **alkoxide ion**, RO^- , the alkyl group is **electron-donating**: it pushes extra electron density onto the already negative oxygen, which **destabilises** the ion. So alcohols (pK_a about 16) are slightly **weaker acids than water** (pK_a 15.7), and much weaker than **phenol** (pK_a 10.0), whose charge is delocalised into the ring. The order is **ethanol < water < phenol < ethanoic acid**. Alcohols react with **acyl chlorides** at room temperature to give **esters** and HCl ; unlike esterification with a carboxylic acid, this needs no catalyst and is not reversible.

the more stable the anion, the stronger the acid

	acid	pK_a	the anion it forms
↑ stronger acid	ethanoic acid	4.76	– charge shared by two O atoms
	phenol	10.0	– charge spread into the ring
	water	15.7	– charge on one O atom
	ethanol	about 16	alkyl group pushes e^- onto O

Fig. 1: acid strength depends on how well the anion holds its negative charge

Anion stability decides; acyl chlorides go to completion.

- ✓ **Order:** ethanol < water < phenol < ethanoic acid.
- ✓ **Alkyl group:** electron-donating, destabilises RO^- .
- ✓ **$K_a = 10^{-\text{p}K_a}$:** one pKa unit is a factor of 10.
- ✓ **$\text{RCOCl} + \text{R}'\text{OH}$:** ester + HCl, room temperature, not reversible.

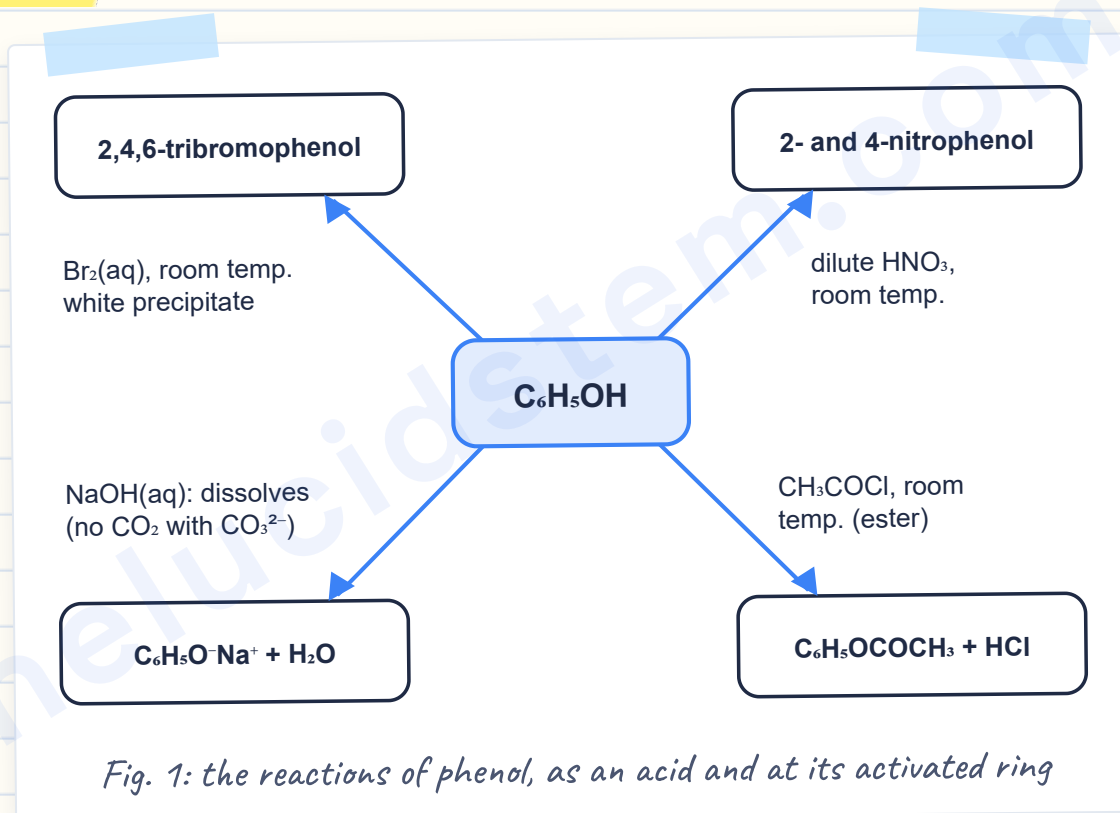
Watch out!

Alcohols are **weaker** acids than water, not stronger; the alkyl group is **electron-donating** and destabilises the alkoxide ion. Do not say the alkyl group 'strengthens the O-H bond' as the whole explanation; the mark is for the **anion stability**. With an acyl chloride the by-product is **HCl**, not water, and the reaction is **not reversible** and needs no acid catalyst.

2 Phenol

Syllabus 32.2

Phenol, C_6H_5OH , is made by **diazotising phenylamine** with $NaNO_2$ and HCl below $10\text{ }^\circ C$, then **warming the diazonium salt with water**, which releases N_2 . A lone pair on the O **overlaps with the delocalised ring**. This spreads the charge of the **phenoxide ion** into the ring, so phenol ($pK_a\ 10.0$) is a **weak acid**: it reacts with Na and $NaOH$ but is too weak to release CO_2 from carbonates. The same overlap raises the electron density of the ring, **activating** it at the **2-, 4- and 6-positions**: phenol decolourises **bromine water** at room temperature to give a **white precipitate of 2,4,6-tribromophenol**, is nitrated by **dilute HNO_3** , and couples with diazonium salts to give **azo dyes**. Phenol forms esters with **acyl chlorides**, not with carboxylic acids.



Weak acid, very reactive ring.

- ✓ **Making it:** NaNO_2/HCl below 10°C , then warm with water.
- ✓ **Acid:** reacts with Na and NaOH , not with carbonates.
- ✓ **$\text{Br}_2(\text{aq})$:** white 2,4,6-tribromophenol, no catalyst.
- ✓ **Esters:** acyl chloride only; azo dyes with diazonium salts.

Watch out!

Phenol does **not** react with carbonates: it is too weak an acid to release CO_2 , which is how it is told apart from a carboxylic acid. Bromine water gives **2,4,6-tribromophenol** (three Br , 3HBr) with **no halogen carrier**. Nitration of phenol uses **dilute** HNO_3 and gives a mixture of 2- and 4-nitrophenol. Esters of phenol are made with an **acyl chloride**, never by heating with a carboxylic acid.